

## SELF-VENTING VALVE

### Background of the Invention

5     **[0001]**     This invention relates to a self-venting valve for providing, and controlling the rate of, a smooth and continuous fluid flow.

10     **[0002]**     It is known to provide molded plastic valves for dispensing liquid from containers, in particular disposable containers of the type popular for holding a liquid such as water, juice or detergent. One well known type of valve for this purpose is a so-called "rotary" valve. In this type of valve, a handle is rotatably actuated by a user to rotate a valve core within a valve housing that is attached to a container. Rotation of the core aligns an aperture in the core with an aperture in the housing to provide a passageway that allows liquid to flow from the container.

15     **[0003]**     An alternative to the rotary valve is a so-called "push button" valve. This type has a resilient plastic valve diaphragm which, when pressed by a user, opens an aperture provided in the valve housing to allow liquid to flow from the container. The resilient

plastic diaphragm, commonly referred to as a "push button", can be arranged so that it positively seals the aperture when manual pressure is removed, thus providing for a self-closing valve. Tap valves of this type require the user to provide manual pressure to the push button throughout the liquid dispensing process, which can be inconvenient when dispensing large quantities of a liquid, particularly when one of the user's hands is needed to hold a receptacle, such as a drinking glass, leaving only one hand to actuate the push button.

**[0004]** Effective metering of the flow rate is generally more difficult to achieve with push button valves than it is with rotary valves. In practice, push button valves provide substantially only "ON/OFF" operation.

**[0005]** Also, there are known slide valves that require a user to push or pull a part of the valve in a certain direction to actuate the valve, but actuation of such a valve may cause the container to unintentionally slide in that direction. If, as is commonly the case, that direction is toward the user, the container could be pulled off the surface it is resting on, unless one hand is used to restrain the container. However, the user's second hand normally would be occupied holding the drinking glass or other receptacle.

**[0006]** Regardless of the valve type used, when a liquid is dispensed through an aperture in a container and valve, ambient pressure above the liquid level in the container drops and creates a partial vacuum. This vacuum must be filled by a volume of fluid -- generally air -- equal to the volume of liquid that has been

removed to equalize the pressure within the container. In early containers, the pressure was equalized by external air drawn into the container through the same valve aperture through which the liquid exited the container. However, in such an arrangement, the external air attempting to enter the container would disrupt the outflow of liquid attempting to exit the container, thereby causing discontinuous liquid flow (i.e., "glugging") and reducing the outflow rate.

5  
10 **[0007]** It is known that continuous and smooth liquid flow can be achieved using containers that are capable of collapsing as liquid flows therefrom or using containers that are vented, because these types of containers are able to decrease the magnitude of the partial vacuum created above the liquid level inside the container without requiring air to flow into the container through the valve. However, a collapsible container, such as a balloon or bag, for example, may be easily damaged and may not be easily attached to a valve. A vented container may allow the contents to be spoiled by substantially continuous exposure to air and to be spilled from the vent. These problems can be addressed by providing a vent that is sealed until opened by the user (e.g., by puncturing), but once the vent is unsealed, spillage and spoilage become possible. A reclosable vent can be provided, but users are unlikely to bother reclosing the vent.

25  
30 **[0008]** Accordingly, it would be advantageous to be able to provide a container with a valve that provides a smooth and continuous outflow of liquid therefrom by maintaining neutral atmospheric pressure within the container while dispensing the liquid, even when the

container is unvented or substantially rigid, and that allows the liquid outflow rate to be varied.

Summary of the Invention

5     **[0009]**     It is an object of this invention to provide a container with a valve that provides a smooth and continuous outflow of liquid therefrom by maintaining neutral atmospheric pressure within the container while dispensing the liquid, even when the container is unvented or substantially rigid.

10    **[0010]**     It is also an object of this invention to provide such a valve that allows the liquid outflow rate to be varied.

15    **[0011]**     In accordance with the present invention, there is provided a container with a valve assembly for providing to a user continuous liquid flow. The container has an orifice in a side-wall, and the orifice has a valve attachment to which the valve assembly is attached in communication with the orifice. The valve assembly comprises a valve housing that  
20    includes a housing body portion. The housing body portion has an air-back aperture and a liquid-out aperture in a first side facing the orifice, a spout in a second side facing away from the orifice, and a substantially hollow interior between the first side  
25    and the second side. The valve housing also includes a housing attachment that extends from the air-back aperture and the liquid-out aperture on the first side and that attaches the housing body portion to the valve attachment. The valve assembly also comprises a valve  
30    core that includes a core body. The core body has a liquid-out passageway and an air-back passageway and moves within the hollow interior to register the

liquid-out passageway with the liquid-out aperture and the spout to control liquid flow through the liquid-out passageway, and to register the air-back passageway with the air-back aperture and the spout to control fluid flow through the air-back passageway between the air-back aperture and the spout.

#### Brief Description of the Drawings

**[0012]** The above and other advantages of the invention will be more apparent upon consideration of the following detailed description, taken in conjunction with the accompanying drawings, in which like reference characters refer to like parts throughout, and in which:

**[0013]** FIG. 1 is a front elevational view of a preferred embodiment of a valve housing according to the present invention;

**[0014]** FIG. 2 is a side elevational view of the valve housing of FIG. 1, taken from line 2-2 of FIG. 1;

**[0015]** FIG. 3A is a rear elevational view of the valve housing of FIGS. 1 and 2, taken from line 3A-3A of FIG. 2, but with most of the fitment omitted;

**[0016]** FIGS. 3B and 3C are vertical cross-sectional views of the valve housing of FIGS. 1-3A, taken from line 3B of FIG. 1, cooperating with a container;

**[0017]** FIG. 4 is a side elevational view of a preferred embodiment of a valve core according to the present invention;

**[0018]** FIG. 5 is an elevational view of the valve core of FIG. 4, taken from line 5-5 of FIG. 4;

**[0019]** FIG. 6 is an elevational view of the valve core of FIGS. 4 and 5, taken from line 6-6 of FIG. 5;

**[0020]** FIG. 7 is an elevational view of the valve core of FIGS. 4-6, taken from line 7-7 of FIG. 6;

**[0021]** FIG. 8 is an end view of the valve core of FIGS. 4-7, taken from line 8-8 of FIG. 7;

5 **[0022]** FIGS. 9-14 are side views of an assembled valve of the present invention in various stages of actuation;

**[0023]** FIG. 15 is a front elevational view of the valve assembly of FIGS. 9-14, in the stage of actuation represented by FIG. 9, taken from line 15-15 of FIG. 9;

**[0024]** FIG. 16 is a vertical cross-sectional view of the valve assembly of FIGS. 9-15, taken from line 16-16 of FIG. 15;

15 **[0025]** FIG. 17 is a vertical cross-sectional view of the valve assembly of FIGS. 9-16, taken from line 17-17 of FIG. 15;

**[0026]** FIG. 18 is a rear elevational view of the valve assembly of FIGS. 9-17, taken from line 18-18 of FIG. 16, but with most of the fitment element omitted;

20 **[0027]** FIG. 19 is a front elevational view of the valve assembly of FIGS. 9-18, similar to FIG. 15, but in the stage of actuation represented by FIG. 10, taken from line 19-19 of FIG. 10;

**[0028]** FIG. 20 is a vertical cross-sectional view of the valve assembly of FIGS. 9-19, taken from line 20-20 of FIG. 19;

**[0029]** FIG. 21 is a vertical cross-sectional view of the valve assembly of FIGS. 9-20, taken from line 21-21 of FIG. 19;

30 **[0030]** FIG. 22 is a rear elevational view of the valve assembly of FIGS. 9-21, taken from line 22-22 of FIG. 20, but with most of the fitment element omitted;

**[0031]** FIG. 23 is a front elevational view of the valve assembly of FIGS. 9-22, similar to FIGS. 15 and 19, but in the stage of actuation represented by FIG. 11, taken from line 23-23 of FIG. 11;

5 **[0032]** FIG. 24 is a vertical cross-sectional view of the valve assembly of FIGS. 9-23, taken from line 24-24 of FIG. 23;

**[0033]** FIG. 25 is a vertical cross-sectional view of the valve assembly of FIGS. 9-24, taken from line 25-25 of FIG. 23;

**[0034]** FIG. 26 is a rear elevational view of the valve assembly of FIGS. 9-25, taken from line 26-26 of FIG. 24, but with most of the fitment element omitted;

15 **[0035]** FIG. 27 is a front elevational view of the valve assembly of FIGS. 9-26, similar to FIGS. 15, 19, and 23, but in the stage of actuation represented by FIG. 12, taken from line 27-27 of FIG. 12;

**[0036]** FIG. 28 is a vertical cross-sectional view of the valve assembly of FIGS. 9-27, taken from line 28-28 of FIG. 27;

**[0037]** FIG. 29 is a vertical cross-sectional view of the valve assembly of FIGS. 9-28, taken from line 29-29 of FIG. 27;

25 **[0038]** FIG. 30 is a rear elevational view of the valve assembly of FIGS. 9-29, taken from line 30-30 of FIG. 28, but with most of the fitment element omitted;

**[0039]** FIG. 31 is a front elevational view of the valve assembly of FIGS. 9-30, similar to FIGS. 15, 19, 23, and 27, but in the stage of actuation represented by FIG. 13, taken from line 31-31 of FIG. 13;

30 **[0040]** FIG. 32 is a vertical cross-sectional view of the valve assembly of FIGS. 9-31, taken from line 32-32 of FIG. 31;

**[0041]** FIG. 33 is a vertical cross-sectional view of the valve assembly of FIGS. 9-32, taken from line 33-33 of FIG. 31;

5 **[0042]** FIG. 34 is a rear elevational view of the valve assembly of FIGS. 9-33, taken from line 34-34 of FIG. 32, but with most of the fitment element omitted;

**[0043]** FIG. 35 is a partially sectional perspective view of the valve assembly of FIGS. 9-34, taken from line 35-35 of FIG. 31;

10 **[0044]** FIG. 36 is a partially sectional perspective view of the valve assembly of FIGS. 9-35, taken from line 36-36 of FIG. 31;

**[0045]** FIG. 37 is a partially sectional perspective view of the valve assembly of FIGS. 9-36, taken from  
15 line 37-37 of FIG. 31;

**[0046]** FIG. 38 is a side elevational view of a second embodiment of a valve core according to the present invention;

20 **[0047]** FIG. 39 is a side elevational view of the valve core of FIG. 38, taken from line 39-39 of FIG. 38;

**[0048]** FIG. 40 is a side elevational view of the valve core of FIGS. 38 and 39, taken from line 40-40 of FIG. 39;

25 **[0049]** FIG. 41 is a side elevational view of the valve core of FIGS. 38-40, taken from line 41-41 of FIG. 40;

30 **[0050]** FIG. 42 is a front elevational view, similar to FIG. 15, of a second embodiment of a valve assembly according to the present invention, incorporating the core of FIGS. 38-41, in the stage of actuation represented by FIG. 9, taken from line 42-42 of FIG. 9;



**[0051]** FIG. 43 is a vertical cross-sectional view of the valve assembly of FIG. 42, taken from line 43-43 of FIG. 42;

**[0052]** FIG. 44 is a vertical cross-sectional view of the valve assembly of FIGS. 42 and 43, taken from line 44-44 of FIG. 42;

**[0053]** FIG. 45 is a rear elevational view of the valve assembly of FIGS. 42-44, taken from line 45-45 of FIG. 43, but with most of the fitment element omitted;

**[0054]** FIG. 46 is a front elevational view of the valve assembly of FIGS. 42-45, similar to FIG. 42, but in the stage of actuation represented by FIG. 13, taken from line 46-46 of FIG. 13;

**[0055]** FIG. 47 is a vertical cross-sectional view of the valve assembly of FIGS. 42-46, taken from line 47-47 of FIG. 46;

**[0056]** FIG. 48 is a vertical cross-sectional view of the valve assembly of FIGS. 43-47, taken from line 48-48 of FIG. 46;

**[0057]** FIG. 49 is a rear elevational view of the valve assembly of FIGS. 42-48, taken from line 49-49 of FIG. 47, but with most of the fitment element omitted;

**[0058]** FIG. 50 is a side elevational view of a third embodiment of a valve core according to the present invention;

**[0059]** FIG. 51 is a side elevational view of the valve core of FIG. 50, taken from line 51-51 of FIG. 50;

**[0060]** FIG. 52 is a side elevational view of the valve core of FIGS. 50 and 51, taken from line 52-52 of FIG. 51;

**[0061]** FIG. 53 is a side elevational view of the valve core of FIGS. 50-52, taken from line 53-53 of FIG. 52;

**[0062]** FIG. 54 is a front elevational view, similar to FIG. 15, of a third embodiment of a valve assembly according to the present invention, incorporating the core of FIGS. 50-53, in the stage of actuation represented by FIG. 9, taken from line 54-54 of FIG. 9;

**[0063]** FIG. 55 is a vertical cross-sectional view of the valve assembly of FIG. 54, taken from line 55-55 of FIG. 54;

**[0064]** FIG. 56 is a vertical cross-sectional view of the valve assembly of FIGS. 54 and 55, taken from line 55-55 of FIG. 54;

**[0065]** FIG. 57 is a rear elevational view of the valve assembly of FIGS. 54-56, taken from line 57-57 of FIG. 55, but with most of the fitment element omitted;

**[0066]** FIG. 58 is a front elevational view of the valve assembly of FIGS. 54-57, similar to FIG. 54, but in the stage of actuation represented by FIG. 13, taken from line 58-58 of FIG. 13;

**[0067]** FIG. 59 is a vertical cross-sectional view of the valve assembly of FIGS. 54-58, taken from line 59-59 of FIG. 58;

**[0068]** FIG. 60 is a vertical cross-sectional view of the valve assembly of FIGS. 54-59, taken from line 60-60 of FIG. 58;

**[0069]** FIG. 61 is a rear elevational view of the valve assembly of FIGS. 54-60, taken from line 61-61 of FIG. 59, but with most of the fitment element omitted;

**[0070]** FIG. 62 is a front elevational view of a second embodiment of a valve housing according to the present invention;

**[0071]** FIG. 63 is a side elevational view of the valve housing of FIG. 62, taken from line 63-63 of FIG. 62;

5 **[0072]** FIG. 64 is a rear elevational view of the valve housing of FIGS. 62 and 63, taken from line 64-64 of FIG. 63, but with most of the fitment element omitted;

10 **[0073]** FIG. 65 is a top elevational view of the valve housing of FIGS. 62-64, taken from line 65-65 of FIG. 64;

**[0074]** FIG. 66 is a front elevational view of a fourth embodiment of a valve core according to the present invention;

15 **[0075]** FIG. 67 is an end view of the valve core of FIG. 66, taken from line 67-67 of FIG. 66;

**[0076]** FIG. 68 is a rear elevational view of the valve core of FIGS. 66 and 67, taken from line 68-68 of FIG. 67;

20 **[0077]** FIGS. 69-71 are front elevational views of an assembled valve of the present invention, incorporating the housing of FIGS. 62-65 and the core of FIGS. 66-68, in different stages of actuation, but with a portion of the fitment element omitted;

25 **[0078]** FIG. 72 is a vertical cross-sectional view of the valve assembly of FIGS. 69-71, taken from line 72-72 of FIG. 69;

**[0079]** FIG. 73 is a vertical cross-sectional view of the valve assembly of FIGS. 69-72, taken from line 73-73 of FIG. 69;

30 **[0080]** FIG. 74 is a vertical cross-sectional view of the valve assembly of FIGS. 69-73, taken from line 74-74 of FIG. 70;

**[0081]** FIG. 75 is a vertical cross-sectional view of the valve assembly of FIGS. 69-74, taken from line 75-75 of FIG. 71;

**[0082]** FIG. 76 is a vertical cross-sectional view of the valve assembly of FIGS. 69-75, taken from line 76-76 of FIG. 71;

**[0083]** FIG. 77 is a rear elevational view of a dust cover according to the present invention; and

**[0084]** FIG. 78 is a partially sectional side view of the dust cover of FIG. 77, taken from line 78-78 of FIG. 77, cooperating with the valve assembly of FIG. 9.

#### Detailed Description of the Invention

**[0085]** The present invention provides dispensing of a smooth and continuous flow of liquid from a rigid or unvented container through a valve assembly having a housing attached to the container, and a core that is movable, and particularly rotatable, within the housing to provide both a liquid-out passageway and an at least partially separate air-return passageway between the container and the ambient atmosphere. Preferably, the core has a handle or actuator that is rotatable by one hand of a user. Also preferably, the housing and core cooperate to allow metering of the liquid outflow rate. The user, preferably, can let go of the actuator once the desired liquid outflow rate is achieved and the valve assembly will remain in that position to dispense liquid until closed by the user.

**[0086]** Because an air-back passageway is at least in part formed separately from the liquid-out passageway, air can flow into the container simultaneously with the dispensing of liquid therefrom. Thus, the pressure can continuously be equalized between the exterior of the

container and the interior of the container above the liquid level, so that the liquid will flow smoothly and at a controllable rate dictated by the relative position of the housing and the core, without requiring  
5 venting or the provision of a collapsible container.

**[0087]** In accordance with the invention, the valve housing preferably has a hollow interior, an air-back aperture, a liquid-out aperture, a spout, and an attachment that may attach to a container. The valve  
10 core preferably has a handle or actuator attached thereto for moving the core relative to the housing to control both the size of the air-back passageway preferably provided between the air-back aperture and the spout, and the size of the liquid-out passageway  
15 preferably provided between the liquid-out aperture and the spout. The air-back aperture and the liquid-out aperture may be generally adjacent one another, but the air-back aperture should be at least partially above the liquid-out aperture, so that the liquid pressure at  
20 the container end of the air-back passageway is less than that at the container end of the liquid-out passageway. This pressure differential may be enhanced by extending an extension tube within the container upward from the air-back aperture into the container.

**[0088]** As stated above, the core is preferably  
25 rotated, but other types of movement can be used. For example, the core may translate or slide. Alternatively, a combination of movements can be used. For example, the core could primarily rotate, but there  
30 could be a translational component to the movement as well. As the core is moved, the degree of registration of each respective passageway with the spout and with its corresponding aperture preferably changes. Upon

initial actuation of the actuator or handle to move the core, liquid will begin to flow from the full or previously unopened container, through both passageways, to the spout as the passageways begin to register with the apertures. As liquid flows out of the container, the ambient pressure above the liquid level inside the container will drop, thereby creating a partial vacuum.

**[0089]** As the ambient pressure above the liquid level inside the container drops below the external ambient pressure, the partial vacuum thereby created preferably draws air into the container through the air-back passageway, displacing the liquid already in that passageway. Air preferably will enter the air-back passageway, and not the liquid-out passageway, because of the aforementioned lower pressure at the container end of the air-back passageway. Also, this passageway is preferably made narrower than the liquid-out passageway so that the amount of liquid to be displaced by air in the air-back passageway is less than that in the liquid-out passageway. This also will favor establishment of the air-back flow in this passageway. The relative sizes of the passageways preferably depend upon various factors including the range of desired rate of liquid flow from the container, the viscosity of the liquid, and the relative heights of the air-back aperture and liquid-out aperture in the container, etc.

**[0090]** Once air begins to flow into the container, this effect preferably is self-sustaining throughout further actuation of the core in both the opening and closing directions of the valve, until the valve is completely closed, as long as a partial vacuum exists

above the liquid level. Preferably, the seal between the valve assembly and the container and the seal between the valve housing and the valve core are sufficient to maintain a degree of partial vacuum  
5 inside the container when the valve is completely closed, so that the air-back effect is immediate upon reopening of the valve. If the vacuum is not maintained when the valve is closed, then the next time the valve is opened, operation will be similar to the  
10 initial time that the valve was opened.

**[0091]** In one embodiment, the liquid-out passageway is formed within a hollow interior of the core between two openings formed in the surface of the core, and the air-back passageway is formed about the core along a  
15 channel formed in the surface of the core. In a second embodiment, both the air-back passageway and the liquid-out passageway are formed about the core along respective channels formed into the surface of the core. In a third embodiment, both the air-back  
20 passageway and the liquid-out passageway are formed by respective passageways within the hollow interior of the core between respective pairs of openings formed in the surface of the core.

**[0092]** A tamper-evident seal preferably is provided.  
25 This seal preferably also acts as a dust cover to keep dust and debris out of the spout prior to initial use and between uses (if replaced by the user). Preferably, the seal also engages with the valve to prevent valve actuation when the seal is in place.

30 **[0093]** The invention will now be described with reference to FIGS. 1-78.

**[0094]** FIGS. 1-3C show a preferred embodiment of a valve housing 12 and FIGS. 4-8 show a preferred

embodiment of a valve core 32 according to the present invention.

**[0095]** As seen in FIGS. 1-3A, valve housing 12 preferably includes a hollow substantially cylindrical body portion 14 attached to a container fitment portion 16, which preferably extends from periphery or surface section 18 of body portion 14 substantially perpendicularly to longitudinal axis A of body portion 14. Preferably, two apertures -- a liquid-out aperture 20 and an air-back aperture 22 -- are formed through periphery 18 of body portion 14 to allow liquid and air to move between the hollow of body portion 14 and fitment portion 16, although any larger number of apertures may be provided.

**[0096]** In a preferred embodiment, liquid-out aperture 20 is substantially rectangular, having a height H and a length L, and air-back aperture 22 is substantially circular, having a diameter d. In addition, a distance h substantially separates the top of aperture 20 from the top of aperture 22, as shown, to provide a pressure difference between the container end of air-back aperture 22 and the container end of liquid-back aperture 20. Instead of or in addition to a distance h separating the tops of the apertures, extension tube 23 (see FIG. 3C) preferably is provided to lower the pressure at the container end of air-back aperture 22 even more as compared to that at the container end of liquid-out aperture 20, for reasons explained above. Opposite fitment portion 16, a spout portion 24 preferably extends from body portion 14 for dispensing liquid from body portion 14 to a user and for supplying external air to body portion 14. Preferably, spout 24 provides a substantially circular



opening, having a diameter D. The shape and size of spout 24 may be chosen to substantially match the aperture of a variety of receptacles to be filled by the user.

5    **[0097]**     Body portion 14 is shown extending along longitudinal axis A, from a preferably open end 26, past spout portion 24 and apertures 20 and 22, to a closed end 28, although end 28 may conceivably be open, as long as a liquid tight seal can be formed at that  
10   end between body portion 14 and valve core 32 in the assembled valve. In a more particularly preferred embodiment, open end 26 includes an actuation stop 27 for limiting the actuation range of a valve core (described below). Housing 12 may be formed from any  
15   suitable material such as high-density polyethylene, low-density polyethylene, polypropylene, linear low-density polyethylene, or other polymer.

**[0098]**     Fitment portion 16 preferably includes screw threads 30 to allow attachment of housing 12 to a  
20   threaded collar around an orifice in a side-wall of a liquid container (not shown). It will be appreciated that housing 12 may be attached to a container in other ways, such as with a snap-fitted collar, or by gluing or ultrasonic welding, etc. It should be noted that  
25   this attachment may be made at any angle relative to the bottom of the container (i.e., relative to the liquid level inside the container).

**[0099]**     Each of FIGS. 3B and 3C shows a portion of valve housing 12 attached to a side-wall of a  
30   container. So that the liquid pressure at the container end of the air-back passageway is less than the liquid pressure at the container end of the liquid-out passageway, for reasons stated above, the height of

the liquid level above the container end of air-back aperture 22 preferably should be less than that above the container end of liquid-out aperture 20. In FIG. 3B, side-wall 1s forms right angle  $\theta$  with bottom-wall 1b of container 1, and the liquid level in container 1 is at height X above the top of liquid-out aperture 20. In this embodiment, the liquid pressure at the container end of air-back aperture 22 is less than the liquid pressure at the container end of liquid-out aperture 20 because the height of the liquid level above aperture 20 exceeds the height of the liquid level above aperture 22 by distance h, as shown.

**[0100]** In FIG. 3C, side-wall 1s<sub>1</sub> forms oblique angle  $\theta_1$  with bottom-wall 1b<sub>1</sub> of container 1<sub>1</sub>, and the liquid level in container 1<sub>1</sub> again is at height X above the top of liquid-out aperture 20. In this embodiment, the liquid pressure at the container end of air-back aperture 22 is less than the liquid pressure at the container end of liquid-out aperture 20 because the height of the liquid level above aperture 20 exceeds the height of the liquid level above aperture 22 by a distance  $h \sin \theta_1$ , as shown.

**[0101]** Without an extension tube, the difference between the liquid pressure at aperture 20 and the liquid pressure at aperture 22 will be less in the embodiment shown in FIG. 3C than in the embodiment shown in FIG. 3B because distance  $h \sin \theta_1$  will always be less than distance h. However, when valve housing 12 is provided with an extension tube 23 having a length  $l$ , the difference between the liquid pressure at aperture 20 and the liquid pressure at aperture 22 in FIG. 3C increases because the difference between the height of the liquid level above aperture 22 and the

height of the liquid level above aperture 20 increases by a distance  $l\cos\theta_1$ , as shown. If extension tube 23 is provided, the tops of apertures 20 and 22 need not be separated by a distance  $h$ , because distance  $l\cos\theta_1$  allows the liquid pressure at the container end of air-back aperture 22 to be less than the liquid pressure at the container end of liquid-out aperture 20. Extension tube 23 may be integrally molded as part of valve housing 12 or it may be part of a separate assembly. The length and diameter of extension tube 23 may be chosen to provide the most user-friendly range of liquid outflow rates based upon the angle between the side-wall and bottom-wall of the container, the volume and rigidity of the container, and the liquid to be dispensed. Extension tube 23 does not affect the difference between the liquid pressure at aperture 20 and the liquid pressure at aperture 22 in FIG. 3B. Therefore, in the configuration shown in FIG. 3B, extension tube 23 would be of no use. However, extension tube 23 may be upwardly curved to affect the difference between the liquid pressure at aperture 20 and the liquid pressure at aperture 22 in FIG. 3B. It should be noted that a higher extension tube allows more air flow up into the container, but only until the point where the inflow volume of air through the valve assembly matches the maximum outflow volume of liquid through the valve assembly. Furthermore, it should be noted that when the valve assembly is used with a collapsible container, such as a balloon or bag, for example, the magnitude of the partial vacuum created above the liquid level inside the container decreases, thereby reducing the need for

air to be drawn into the container through the air-back passageway.

- [0102]** Preferably, and as shown in FIGS. 1-3C, housing 12 includes top flanges 17 to provide the user with a grip in order to move the valve assembly and container in a refrigerator or on a counter, for example. If a handle is only provided on the top of the container, the lack of a grip area on the front of the container may sometimes force the user to use valve housing 12 as a handle in order to move the container. Flanges 17 preferably give the user's thumb a place to grip as his or her fingers wrap around the back and bottom of housing 12 to facilitate movement of the container.
- [0103]** As seen in FIGS. 4-8, valve core 32 preferably includes a substantially cylindrical and hollow valve core body 34 having a longitudinal axis  $A_1$  (which when assembled with valve housing 12 preferably is substantially coincident with axis A of FIGS. 1-3). There is also attached at one end a handle or actuator 36, which preferably is substantially perpendicular to the longitudinal axis  $A_1$  of core body 34. Preferably, a liquid-out passageway 38 (see FIGS. 16-37) is formed within core body 34, between an exterior-facing opening 40 and a container-facing opening 42, which are formed through the peripheral surface of core body 34. In a preferred embodiment, exterior-facing opening 40 is substantially semicircular, having a diameter  $D_1$ , and container-facing opening 42 is substantially rectangular, having a height  $H_1$  and a length  $L_1$ , as shown. An air channel 46 preferably is formed into the peripheral surface of core body 34 to form an air-back passageway 44 about

core body 34 (see FIGS. 17-37) when core 32 is assembled with housing 12 to form a valve assembly of the present invention. In a preferred embodiment, air channel 46 is formed into the surface of core body 34 to a depth  $t$ , and extends circumferentially about core body 34 from a first end  $j$  to a second end  $k$ .

Preferably, channel 46 is wider at second end  $k$  than at first end  $j$  such that a portion of channel 46 at second end  $k$  extends away from handle 36 to at least a point  $Z$  along the length of core body 34, for reasons to be explained below.

**[0104]** Core body 34 is shown to extend along longitudinal axis  $A_1$ , from a preferably open end 33, past openings 40 and 42, and air channel 46, to a closed end 35 shared by handle 36, although end 33 may conceivably be closed in other embodiments. In a more particularly preferred embodiment, core 32 includes an actuation track 37. Track 37 is formed into the periphery of handle 36 closest to end 35, from a point  $F$  to a point  $E$ , for limiting the actuation range of core 32 within body portion 14 (described in more detail below). Like valve body portion 14, valve core 32 may be formed from any suitable material such as high-density polyethylene, low-density polyethylene, polypropylene, linear low-density polyethylene, or other polymer, and preferably is of the same material as body portion 14. It should be noted that core body 34 described above is only exemplary and need not be hollow, and that, in an other embodiment (not shown), core body 34 could be substantially solid and the passageways could be formed through and/or about the solid of the core body.

**[0105]** FIGS. 9-37 show how valve housing 12 of FIGS. 1-3C and valve core 32 of FIGS. 4-8 may be combined to form valve assembly 10 of the present invention. Preferably, core body 34 creates a seal within the hollow of cylindrical body portion 14 and is rotatable about longitudinal axis A, which is shared by core body 34 and body portion 14. Through rotation of handle 36 about axis A, and therefore through rotation of core body 34 within body portion 14, the geometry of housing 12 and core 32 (described above) preferably regulates not only the flow of liquid from a container, through liquid-out aperture 20, liquid-out passageway 38, and spout 24 to the user, but also the supply of external air through spout 24, air-back passageway 44, and air-back aperture 22 to the interior of the container above the liquid level. Once a partial vacuum is created inside the container, this geometry also preferably provides a seal between the housing and the core that is sufficient to substantially maintain the partial vacuum inside the container after the valve is closed. Valve assembly 10 may provide the liquid and air-tight seal between the elements of housing 12 and core 32, and between the container and its ambient environment, through the use of standard surface-to-surface interference fits or through the use of gaskets, such as molded seal beads around the ends of the core body and at the perimeter of each end of each passageway (not shown for the sake of clarity of the drawings), for example.

**[0106]** FIGS. 9-13 are end views of valve assembly 10 having core 32 rotated to five different positions, as indicated by the orientations of handle 36. FIG. 9 shows valve assembly 10 in a "closed" position. In

this position, handle 36 is shown to have essentially a  $0^\circ$  actuation angle with respect to a vertical line V that is substantially perpendicular to axis A (not shown), ("vertical" being understood in the sense of  
5 FIGS. 9-13; the actual angle will be a function of the incline of the surface of the container to which valve assembly 10 is attached (see FIGS. 3B and 3C)). As seen by the orientation of handle 36 in FIG. 9, the interaction of actuation stop 27 with point F of  
10 actuation track 37 preferably prevents handle 36 from rotating beyond this position in direction C.

**[0107]** FIG. 10 shows valve assembly 10 in a "minimally ON" position, in which handle 36 has been rotated in direction W or C about axis A to an  
15 actuation angle  $\alpha$  with respect to V. FIG. 11 shows valve assembly 10 in a "halfway ON" position, in which handle 36 has been rotated in direction W or C about axis A to an actuation angle  $\beta$  with respect to V. FIG. 12 shows valve assembly 10 in a "significantly ON"  
20 position, in which handle 36 has been rotated in direction W or C about axis A to an actuation angle  $\gamma$  with respect to V. FIG. 13 shows valve assembly 10 in a "completely ON" position, in which handle 36 has been rotated in direction W about axis A to an actuation  
25 angle  $\delta$  with respect to V. As seen in this drawing, the interaction between actuation stop 27 and point E of actuation track 37 preferably prevents handle 36 from rotating further in direction W, so that handle 36 may not rotate to an actuation angle that allows the  
30 handle to interfere with the receptacle that the user is filling with liquid, for example.

**[0108]** In a more preferred embodiment, shown in FIG. 14, the "closed" position may be defined by

handle 36 forming an actuation angle greater than  $0^\circ$  (i.e.,  $\alpha_1$ ) with respect to V. This may be desirable when the surface of the container closest to the valve assembly makes it difficult for a user to grasp a handle that is vertically aligned with the valve (see FIG. 9). This may be accomplished easily by forming handle 36 and actuation track 37 at a different circumferential position (as compared to FIG. 9) on valve core body 34, and by forming actuation stop 27 at a correspondingly different position (as compared to FIG. 9) on housing portion 14, such that when actuation stop 27 contacts point F of track 37, handle 36 forms the desired angle with respect to V. This feature allows the core to be grippable and actuatable in all positions that could be used while dispensing liquid. In yet another embodiment (not shown), it may be desirable for the "completely ON" position to be defined by handle 36 forming an actuation angle less than angle  $\delta$  with respect to V, so that the handle is less likely to interfere with the receptacle being filled. This may be accomplished by forming handle 36 and actuation track 37 at a different circumferential position (as compared to FIG. 13) on valve core body 34, and by forming actuation stop 27 at a corresponding different position (as compared to FIG. 13) on housing portion 14, as described above with respect to FIG. 14, but such that when actuation stop 27 contacts point E of track 37, handle 36 forms the desired angle with respect to V. In this embodiment, the shape of the container may be modified so that it is easier for the user to grasp the handle when the valve assembly is in the "closed" position.



**[0109]** FIGS. 15-18 show a preferred embodiment of valve assembly 10 in the closed position. Preferably, in this closed position, no portion of container-facing opening 42 is aligned with any portion of liquid-out aperture 20, as shown in FIG. 16. Therefore, no liquid flows through liquid-out passageway 38 within core body 34 between liquid-out aperture 20 and spout 24. Furthermore, no portion of air channel 46 is exposed to any portion of spout 24, as shown in FIGS. 16 and 17, thereby preventing air-back passageway 44 from allowing the movement of air or liquid between spout 24 and air-back aperture 22. Although one end of each of passageways 38 and 44 as shown is always substantially completely open (i.e., substantially all of exterior-facing opening 40 is aligned with spout 24, and substantially all of air-back aperture 22 is aligned with channel 46), other embodiments are envisioned without departing from the scope of the present invention wherein, for example, both ends of each passageway open gradually as the actuation angle grows with respect to V.

**[0110]** FIGS. 19-22 are views similar to FIGS. 15-18, respectively, but show valve assembly 10 in the "minimally ON" position that is shown in FIG. 10. Preferably, in this minimally ON position, core body 34 has been rotated to align both a minimal portion of container-facing opening 42 with a portion of liquid-out aperture 20 and substantially all of exterior-facing opening 40 with spout 24, as shown in FIG. 20, thereby allowing liquid to flow between liquid-out aperture 20 and spout 24 through liquid-out passageway 38. Furthermore, in this minimally ON position, core body 34 preferably has been rotated to

align air channel 46 with both a relatively minimal portion of spout 24, as shown in FIG. 20 by the portion of channel 46 that extends to at least point Z, and substantially all of air-back aperture 22, as shown in  
5 FIG. 21, thereby allowing fluid to flow between air-back aperture 22 and spout 24 through air-back passageway 44. Core body 34 may have additional geometry that further aids the dispensing of liquid from valve assembly 10. For example, container-facing  
10 opening 42 may be formed through the peripheral surface of core body 34 such that "top" edge 39 of opening 42 is not radial, but instead is chamfered relative to the outer periphery of core body 34, as shown in FIG. 20, to guide liquid downwardly from a container through  
15 opening 42 to provide more control to the flow of liquid through liquid-out passageway 38.

**[0111]** FIGS. 23-26 are similar to FIGS. 15-18, respectively, but show valve assembly 10 in the "halfway ON" position that is shown in FIG. 11.  
20 Preferably, in this halfway ON position, core body 34 has been rotated to align both substantially half of container-facing opening 42 with liquid-out aperture 20 and substantially all of exterior-facing opening 40 with spout 24, as shown in FIG. 24, thereby allowing  
25 liquid to flow between liquid-out aperture 20 and spout 24 through liquid-out passageway 38.

Furthermore, in this halfway ON position, core body 34 preferably has been rotated to align air channel 46 with both a bigger portion of the spout (compared to  
30 that in the "minimally ON" position), as shown in FIG. 24 by the portion of channel 46 that extends to at least point Z, and substantially all of air-back aperture 22, as shown in FIG. 25, thereby allowing

fluid to flow between air-back aperture 22 and spout 24 through air-back passageway 44.

[0112] FIGS. 27-30 are similar to FIGS. 15-18, respectively, but show valve assembly 10 in the "significantly ON" position that is shown in FIG. 12. Preferably, in this significantly ON position, core body 34 has been rotated to align both a significant portion of container-facing opening 42 with liquid-out aperture 20 and substantially all of exterior-facing opening 40 with spout 24, as shown in FIG. 28, thereby allowing liquid to flow between liquid-out aperture 20 and spout 24 through liquid-out passageway 38. Furthermore, in this significantly ON position, core body 34 preferably has been rotated to align air channel 46 with both a bigger portion of the spout (compared to that in the "halfway ON" position), as shown in FIG. 28 by the portion of channel 46 that extends to at least point Z, and substantially all of air-back aperture 22, as shown in FIG. 29, thereby allowing fluid to flow between air-back aperture 22 and spout 24 through air-back passageway 44.

[0113] FIGS. 31-34 are similar to FIGS. 15-18, respectively, but, along with FIGS. 35-37, show valve assembly 10 in the "completely ON" position that is shown in FIG. 13. Preferably, in this completely ON position, the interaction of actuation stop 27 and point E of actuation track 37 prevents handle 36 from rotating any further in direction W (see FIG. 13). Preferably, in this completely ON position, core body 34 has been rotated to align both substantially all of container-facing opening 42 with liquid-out aperture 20 and substantially all of exterior-facing opening 40 with spout 24, as shown in FIG. 32, thereby

allowing liquid to flow between liquid-out aperture 20 and spout 24 through liquid-out passageway 38.

Furthermore, in this completely ON position, core body 34 preferably has been rotated to align air channel 46 with both a bigger portion of the spout (compared to that in the "significantly ON" position), as shown in FIG. 32 by the portion of channel 46 that extends to at least point Z and as shown in FIG. 33, and substantially all of air-back aperture 22, as shown in FIG. 33, thereby allowing fluid to flow between air-back aperture 22 and spout 24 through air-back passageway 44.

**[0114]** Although substantially all of air-back aperture 22 is aligned with air channel 46, and substantially all of exterior-facing opening 40 is aligned with spout 24 throughout the rotation of core body 34 in the preferred embodiment of FIGS. 15-37, it is not outside the scope of the invention to provide a valve assembly with geometry such that both ends of passageway 38 and/or 44 align with different portions of the respective apertures and/or spout as the core body is rotated. Moreover, as is seen in FIGS. 15-37, it is preferable that the geometry of air channel 46 and apertures 20 and 22 is such that, in any of the positions described above (and any of the infinite positions therebetween), no portion of air channel 46 is aligned with any portion of liquid-out aperture 20. This ensures that nothing flowing out from liquid-out aperture 20 can flow back into the container through air-back aperture 22 via air-back passageway 44. Preferably, seals, such as those described above, are also provided to help ensure that liquid-out passageway 38 and air-back passageway 44 are

substantially isolated from one another between apertures 20 and 22, and spout 24.

**[0115]** Valve core body 34, as shown in FIGS. 4-37, provides air-back passageway 44 along air channel 46  
5 formed in its surface and liquid-out passageway 38 between openings 40 and 42 formed through its surface. However, in an alternate embodiment of a valve core body of the present invention, the two passageways may both be provided along channels in the surface of a  
10 core rotatable within valve housing 12 for aligning spout 24 with liquid-out aperture 20 and air-back aperture 22. Such an embodiment is shown in FIGS. 38-49.

**[0116]** Valve core 132, shown in FIGS. 38-41, preferably includes a substantially cylindrical valve  
15 core body 134 attached at one end to a handle 136 that preferably is substantially perpendicular to the longitudinal axis  $A_2$  of core body 134. Preferably, a liquid-out passageway 138 (see FIGS. 43 and 47) is  
20 formed about core body 134, along a liquid channel 140 that is formed into the peripheral surface of core body 134. In a preferred embodiment, liquid channel 140 is formed into the surface of core body 134 to a depth  $b$ , and is substantially rectangular in  
25 shape, having a height  $H_2$  and a length  $L_2$ , as shown, although many other shapes may be used without departing from the scope of the present invention. An air-back passageway 144 (see FIGS. 44, 47, and 48), similar to air-back passageway 44, is preferably formed  
30 about core body 134, along an air channel 146 that is formed into the peripheral surface of core body 134. In a preferred embodiment, air channel 146 is formed into the surface of core body 134 to a depth  $t_1$ , and

extends circumferentially about core body 134 from a first end  $j_1$  to a second end  $k_1$ . Preferably, air channel 146 is wider at second end  $k_1$  than at first end  $j_1$ . In this preferred embodiment, a portion of air  
5 channel 146 extends away from handle 136 to at least a point  $Z_1$  along the length of core 132.

**[0117]** Core body 134 is shown to extend substantially along longitudinal axis  $A_2$ , from end 133, past liquid channel 140 and air channel 146, to a  
10 closed end 135 shared by handle 136. In a more particularly preferred embodiment, core 132 includes an actuation track 137. Track 137 is formed into the periphery of handle 136 closest to end 135, from a point  $F_1$  to a point  $E_1$ , for limiting the rotation range  
15 of core 132 within a valve housing (as described above with reference to actuation track 37). Like valve core 32, valve core 132 may be formed from any suitable material such as high-density polyethylene, low-density polyethylene, polypropylene, or linear low-density  
20 polyethylene, and preferably is formed of the same material as body portion 14.

**[0118]** FIGS. 42-49 show how valve housing 12 of FIGS. 1-3C and valve core 132 of FIGS. 38-41 may be combined to form valve assembly 110 of the present  
25 invention. FIGS. 42-45 are similar to FIGS. 15-18, respectively, and FIGS. 46-49 are similar to FIGS. 31-34, respectively, but represent valve assembly 110 instead of valve assembly 10.

**[0119]** Valve core body 34, as shown in FIGS. 4-37, provides air-back passageway 44 along air channel 46  
30 formed in its surface and liquid-out passageway 38 between openings 40 and 42 formed through its surface. However, in an alternate embodiment of a valve core

body of the present invention, the two passageways each may be provided between a respective exterior-facing opening and a respective container-facing opening in a core rotatable within valve housing 12 for aligning  
5 spout 24 with liquid-out aperture 20 and air-back aperture 22. Such an embodiment is shown in FIGS. 50-61.

**[0120]** Valve core 232, shown in FIGS. 50-53, preferably includes a substantially cylindrical and  
10 hollow valve core body 234 attached at one end to a handle 236 that preferably is substantially perpendicular to the longitudinal axis  $A_3$  of core body 234. Preferably, a liquid-out passageway 238 (see FIGS. 55 and 59) is formed within core body 234,  
15 between an exterior-facing opening 240 and a container-facing opening 242 that are formed through the peripheral surface of core body 234. Preferably, container-facing opening 242 is substantially rectangular, having a height  $H_3$  and a length  $L_3$ , as  
20 shown. A substantially separate air-back passageway 244 (see FIGS. 56 and 60) is preferably formed within core body 234, between an container-facing opening 246 and an exterior-facing opening 248 that are formed through the peripheral surface of core  
25 body 234. Preferably, container-facing opening 246 is substantially rectangular, having a height  $G$  and a length  $d_1$ , as shown, although many other shapes may be used without departing from the scope of the present invention.

30 **[0121]** Core body 234 is shown to extend substantially along longitudinal axis  $A_3$ , from a preferably open end 233, across openings 240, 242, 246, and 248, to a preferably closed end 235 shared by

handle 236, although end 233 may conceivably be closed in other embodiments. In a more particularly preferred embodiment, core 232 includes an actuation track 237. Track 237 is formed into the periphery of handle 236  
5 closest to end 235, from a point  $F_2$  to a point  $E_2$ , for limiting the rotation range of core 232 within a valve housing (as described above with reference to actuation track 37). Like valve core 32, valve core 232 may be formed from any suitable material such as high-density  
10 polyethylene, low-density polyethylene, polypropylene, or linear low-density polyethylene, and preferably is formed of the same material as body portion 14.

**[0122]** FIGS. 54-61 show how valve housing 12 of FIGS. 1-3C and valve core 232 of FIGS. 50-53 may be  
15 combined to form valve assembly 210 of the present invention. FIGS. 54-57 are similar to FIGS. 15-18, respectively, and FIGS. 58-61 are similar to FIGS. 31-34, respectively, but represent valve assembly 210 instead of valve assembly 10.

**[0123]** Each of valve assemblies 10, 110, and 210, as shown in FIGS. 9-61, provides a core body within a housing body portion, preferably such that the core body is rotatable about a longitudinal axis shared by the core body and housing body portion preferably to  
25 regulate not only the flow of liquid from a container through a liquid-out passageway but also the flow of fluid between the container and the ambient atmosphere through an air-back passageway. However, in an alternate embodiment of a valve assembly of the present  
30 invention, a valve assembly may be provided in which the core body is translatable along a longitudinal axis shared by the core body and housing body portion, preferably to regulate not only the flow of liquid from



a container through a liquid-out passageway but also the flow of fluid between the container and the ambient atmosphere through an air-back passageway. Such an embodiment is shown in FIGS. 62-75.

5   **[0124]**     Valve housing 312, as shown in FIGS. 62-65 preferably includes a substantially hollow body portion 314 attached to a container fitment portion 316, which preferably extends from periphery or surface section 318 of body portion 314 substantially  
10   perpendicularly to longitudinal axis  $A_4$  of body portion 314. Preferably, two apertures -- a liquid-out aperture 320 and an air-back aperture 322 -- are formed through periphery 318 of body portion 314 to allow liquid and air to move between the hollow of body  
15   portion 314 and fitment portion 316, although any larger number of apertures may be provided.

**[0125]**     In a preferred embodiment, liquid-out aperture 320 is substantially semi-circular, having a diameter  $D_2$ , and air-back aperture 322 is substantially  
20   rectangular, having a height  $d_2$  and a length  $D_3$ , which, for example, may be substantially equal to  $D_2$ . In addition, a distance  $h_1$  substantially separates the top of aperture 320 from the top of aperture 322, as shown, to provide a pressure difference between the container  
25   end of air-back aperture 322 and the container end of liquid-back aperture 320, for reasons explained above with respect to valve assembly 10. Extension tube 323 (not shown) preferably is provided to lower the pressure at the container end of air-back aperture 322  
30   even more as compared to that at the container end of liquid-out aperture 320, for reasons also explained above with respect to valve housing 12 and as shown in FIG. 3C. Opposite fitment portion 316, a spout

portion 324 preferably extends from body portion 314 for dispensing liquid from body portion 314 to a user and for supplying external air to body portion 314.

Preferably, spout 324 provides a substantially

5 "U-shaped" opening, having a diameter  $D_4$  and a side-length  $h_2$ , which, for example, may be substantially equal to  $h_1$ .

**[0126]** Body portion 314 is shown extending along longitudinal axis  $A_4$ , from preferably closed end 326, past spout portion 324 and apertures 320 and 322, to 10 preferably closed end 328. In a more particularly preferred embodiment, an actuation track 321 is formed through periphery 318 of body portion 314 from a point  $F_3$  substantially adjacent apertures 320 and 322 to 15 a point  $E_3$  substantially near end 326, and a pin 319 extends in substantially the same direction as spout 324 from a portion of surface 327 of fitment portion 316 that is separated from periphery 318 as a pivot for an actuator of a valve core (described 20 below). Like valve housing 12, housing 312 may be formed from any suitable material such as high-density polyethylene, low-density polyethylene, polypropylene, linear low-density polyethylene, or other polymer.

**[0127]** Fitment portion 316, similar to fitment 25 portion 16, preferably includes screw threads 330 to allow attachment of housing 312 to a threaded collar around an orifice in a side-wall of a liquid container (not shown). It will be appreciated that housing 312 may be attached to a container in other ways, such as 30 with a snap-fitted collar, or by gluing or ultrasonic welding, etc. It should be noted that this attachment may be made at any angle relative to the bottom of the container (i.e., relative to the liquid level inside

the container), as explained above with respect to valve assembly 10.

- [0128]** As seen in FIGS. 66-68, valve core 332 preferably includes a substantially long and
- 5 substantially solid valve core body 334 having a dispensing side 343 and a source side 345, that extends along a longitudinal axis  $A_5$  (which when assembled with valve housing 312 preferably is substantially coincident with axis  $A_4$  of FIG. 62) from end 333 to
- 10 end 335. In a more particularly preferred embodiment, an extension 347 extends from end 335 along axis  $A_5$  that includes pin 341. However, in an other embodiment, pin 341 could extend from source side 345 near end 335, although the core body might have to be made longer.
- 15 Either way, a handle or actuator 336 preferably rotates at pin 319 of fitment portion 316 about an axis  $A_6$  that is substantially perpendicular to  $A_5$  (see FIG. 74). Slot 339 is preferably formed through handle 336 for converting rotation of handle 336 into translational
- 20 motion of core body 334 by interaction with pin 341. In an other embodiment (not shown), pin 319, and the hole in handle 336, through which pin 319 extends, could be replaced by a molded living hinge, where handle 336 is attached to valve housing 312.
- 25 **[0129]** Preferably, a liquid-out passageway 338 (see FIGS. 70, 71, and 76) is formed by a liquid-out gap 340 through core body 334, between dispensing side 343 and source side 345. In a preferred embodiment, liquid-out gap 340 is substantially semi-circular, having a
- 30 diameter  $D_5$ , which, for example, may be substantially equal to  $D_2$ . Preferably, an air-back passageway 344 (see FIGS. 70, 71, and 76) is formed by an air-back gap 342 through core body 334, between dispensing

side 343 and source side 345. In a preferred embodiment, air-back gap 342 is substantially rectangular, having a height  $d_3$  and a length  $D_6$ , which, for example may be substantially equal to  $d_2$  and  $D_3$ , respectively. Like valve core 32, valve core 332 may be formed from any suitable material such as high-density polyethylene, low-density polyethylene, polypropylene, linear low-density polyethylene, or other polymer, and preferably is of the same material as body portion 314.

**[0130]** FIGS. 69-76 show how valve housing 312 of FIGS. 62-65 and valve core 332 of FIGS. 66-68 may be combined to form valve assembly 310 of the present invention. Preferably, core body 334 creates a seal within the hollow of body portion 314 and is translatable along longitudinal axis  $A_4$ , which is shared by core body 334 and body portion 314. Pin 341 preferably extends through track 321 of body portion 314 and through slot 339 of handle 336.

Through rotation of handle 336 about axis  $A_6$ , and the interaction of pin 341 with slot 339 and the ends of track 321, core body 334 translates within body portion 314 along axis  $A_4$  such that the geometry of housing 312 and core 332 (described above) preferably regulates not only the flow of liquid from a container, through liquid-out aperture 320, liquid-out passageway 338, and spout 324 to the user, but also the supply of external air through spout 324, air-back passageway 344, and air-back aperture 322 to the interior of the container above the liquid level therein. As in the case of valve assemblies 10, 110, and 210, once a partial vacuum is created inside the container, valve assembly 310 also preferably provides

a seal between the housing and the core that is sufficient to substantially maintain the partial vacuum inside the container after the valve is closed.

**[0131]** FIGS. 69-71 are front elevational views of valve assembly 310 having core 332 actuated to two different positions, although there may be an infinite amount of positions therebetween, as indicated by the location of pin 341 between ends  $E_3$  and  $F_3$  of track 321. FIG. 69 shows valve assembly 310 in a "closed" position. In this position, pin 341 of core body 334 is located essentially at end  $F_3$ , and handle 336 is rotated as far as possible in direction  $C_1$ .

**[0132]** Preferably, in this closed position shown in FIG. 69 and also in FIGS. 72 and 73, no portion of liquid-out gap 340 is aligned with any portion of liquid-out aperture 320 and spout 324. Therefore, the solid of core body 334 covers substantially all of liquid-out aperture 320 and spout 324, thereby preventing the flow of liquid through liquid-out passageway 338 within the hollow of body portion 314 between liquid-out aperture 320 and spout 324. Furthermore, no portion of air-back gap 342 is aligned with any portion of air-back aperture 322 and spout 324. Therefore, the solid of core body 334 covers substantially all of air-back aperture 322 and spout 324, thereby preventing the flow of fluid through air-back passageway 344 within the hollow of body portion 314 between air-back aperture 322 and spout 324.

**[0133]** FIG. 70 shows valve assembly 310 in a "halfway ON" position. In this position, pin 341 of core body 334 is essentially halfway between end  $F_3$  and end  $E_3$ .

**[0134]** Preferably, in this halfway ON position shown in FIG. 70 and also in FIG. 74, core body 334 has been translated to align substantially half of liquid-out gap 340 with substantially half of liquid-out aperture 320 and spout 324, thereby allowing liquid to flow between liquid-out aperture 320 and spout 324 through liquid-out passageway 338. Furthermore, in this halfway ON position, core body 334 preferably has been translated to expose substantially half of air-back gap 342 with substantially half of air-back aperture 322 and spout 324, thereby allowing fluid to flow between air-back aperture 322 and spout 324 through air-back passageway 344.

**[0135]** FIG. 71 shows valve assembly 310 in a "completely ON" position. In this position, pin 341 of core body 334 is located essentially at end E<sub>3</sub>, and handle 336 is rotated as far as possible in direction W1.

**[0136]** Preferably, in this completely ON position shown in FIG. 71 and also in FIGS. 75 and 76, core body 334 has been translated to align substantially all of liquid-out gap 340 with substantially all of liquid-out aperture 320 and spout 324, thereby allowing liquid to flow between liquid-out aperture 320 and spout 324 through liquid-out passageway 338. Furthermore, in this completely ON position, core body 334 preferably has been translated to expose substantially all of air-back gap 342 with substantially all of air-back aperture 322 and spout 324, thereby allowing fluid to flow between air-back aperture 322 and spout 324 through air-back passageway 344.

**[0137]** The core body in the embodiment of FIGS. 69-76 moves translationally by actuation of handle 336. Other mechanisms for moving the core translationally can be provided. For example, the core  
5 body and the housing body portion may be threaded so that rotation of the core body, in a manner similar to the embodiments of FIGS. 15, 42, and 54, also causes translation of the core body.

**[0138]** A dust cover 400 for shielding the spout of a  
10 valve assembly of the present invention when it is not dispensing liquid is shown in FIGS. 77 and 78. Cover 400 includes face portion 402, plug portion 404, stop portion 406, and tamper portion 408 with breakaway nub 409. Preferably, face portion 402 is large enough  
15 to cover substantially all of spout 424 of valve assembly 410, which may be similar to assembly 10 and which is partially shown in FIG. 78. Extending away from face 402 is plug portion 404 that is preferably about the same shape as spout 424, but of a size that  
20 can fit within spout 424 when cover 400 is inserted into assembly 410 along direction X. In a preferred embodiment, the relative sizes of the spout and the plug are such that, when inserted into valve assembly 410, it is difficult for cover 400 to be  
25 removed therefrom unintentionally. Stop portion 406 extends from plug 404 to a particular length, such that when cover 400 is inserted into valve assembly 410, stop 406 contacts a portion of valve core body 434 therein to substantially bar actuation of the core to a  
30 position which can permit dispensation of liquid through spout 424. For example, stop 406 may extend into exterior-facing opening 440. Finally, nub 409 of tamper portion 408 may be frangibly affixed to a part

of valve assembly 410 before valve assembly 410 is initially used.

**[0139]** In order to dispense liquid through a valve assembly provided with a dust cover 400 of the present invention, the cover must be removed in a direction  
5 substantially opposite to direction  $X_1$  (as explained above). When initially removed, nub 409 preferably breaks away from valve assembly 410. If a user finds that initial removal is too easy, in that nub 409 need  
10 not be broken off its attachment to valve assembly 410, the user may take that as a sign of tampering. Once initially removed, the user may put dust cover 400 back into its original position in order to keep dirt and debris out of the spout between uses, and preferably  
15 also to prevent actuation of the valve to a position which can permit dispensing of liquid through the spout.

**[0140]** Thus it is seen that a valve assembly for dispensing and controlling a smooth and continuous  
20 outflow of liquid, even from an unvented or rigid container, has been provided. It should be noted that the shapes and sizes of the liquid-out apertures, liquid-out gaps, air-back apertures, air-back gaps, spouts, exterior-facing openings, container-facing  
25 openings, and channels described above are only exemplary. One skilled in the art will appreciate that the present invention can be practiced by other than the described embodiments, which are presented for purposes of illustration and not of limitation, and the  
30 present invention is limited only by the claims which follow.